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Analysis of concentration and accumulation of heavy metal cadmium in four selected terrestrial plants

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ABSTRACT

Contamination of soils with toxic metals has often resulted from human activities, especially those related to mining, industrial emissions, disposal or leakage of industrial wastes, application of sewage sludge to agricultural soils, manure, fertilizer and pesticide use. Phytoremediation is the term applied to a group of technologies that use of plants to reduce, remove, degrade, or immobilize environmental toxins, primarily those of anthropogenic origin with the aim of restoring area sites to conditions usable for private or public applications. Some plants naturally survive in heavy metal contaminated soils because of their ability and accumulate them into their tissues. The ability of these plants to remove contaminants from the soil has been the subject of various recent studies. These plants are normally slow growing and producing small biomass but, they accumulate heavy metals in their tissues lowering the quantity and controlling the movement of heavy metals through the soil profile. From the present study it was found that the heavy metal cadmium accumulation was more in leaves when compared to stem and roots of four experimental plants. The findings show that *Datura innoxia* plant has up taken 80 – 85 % of cadmium from contaminated soil which will have direct application to remediate toxic metals from contaminated soil – water environment. It was noted that *Datura innoxia* is the suitable candidate plant for phytoremediation operation.

INTRODUCTION

Soil polluted with heavy metals is environmental problem that requires an effective and affordable solution. Especially higher concentration of cadmium (Cd) in soil can cause serious problem to environment and also to human health. Although a number of techniques have been developed to remove metals from contaminated soils, many sites remain contaminated because economic and environmental costs to clean up those sites with the available technologies are too high. In this context, phytoremediation has been developed as a cost effective and eco-friendly remediation method of contaminated soils. However, phytoremediation costs atleast ten times less than traditional methods of excavation and removal (1) and if an additional economic incentive were present (not only on environmental benefit) such as photomining on forestry, then phytoremediation would be viewed as economically viable. Cadmium is the heavy metal naturally present in soil at concentration of slightly more than 1 mg kg^{-1} (2). Not only is it non-essential for life, it is highly toxic to most organisms, having a toxicity 2-20 times higher than many other heavy metals (3). It is therefore considered as a very serious pollutant. Plant can extract Cd from the soil and transport it via the xylem into shorts and leaves where it can accumulate (4). In most plant species, cadmium is accumulated in the roots, although the allocation to the shoot may vary considerably between different species. For example, in Sugarbeet, 10 – 20% was transported to the shoot (5), while in Soybean, only 2% of the accumulated Cd reached the leaves (6). The roots of Indian mustard are effective in the removal of Cd, Cr, Cu, Ni, Pb and Zn (7). Inview of the foregoing literature, it is programmed to make an attempt to study the nature of phytoremediation technique in the soils of study area with help of selected terrestrial plants, namely, *Datura innoxia*, *Acacia nilotica*, *Ricinus communis*,and *Calotropis gigantea*.

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MATERIALS METHODS

State Industries Promotion Corporation of Tamilnadu (SIPCOT) industrial estate is located 8 km from Cuddalore on the sea ward side of the Cuddalore, Cuddalore District, Tamilnadu SIPCOT industries reported that they generate 17.7

million litres of efficient per day. The ETP (Effluent Treatment Plant) running 24 hours a day has a capacity of treating 12 million litres of industrial effluents. The SIPCOT industrial complex,cuddalore, covering an area of 519 acres, has been set up in 1982 on the western bank of the uppanar estuary. The complex includes 26 industries and having 13 chemical units and the rest may use chemicals in their manufacturing processing. In addition, effluents from the SIPCOT industrial complex are discharged into the uppanar estuary, which are the major polluting agents of the estuary. The terrestrial plants namely *Datura innoxia, Acacia nilotica, Ricinus communis, Calotropis gigantea* were selected for the present study to prove phytoremedration process took place among certain plants. The test plants were planted into the soils collected from SIPCOT industrial study area. In the present investigation, heavy metal cadmium has been selected, because about three quarters of Cd is used in batteries and most of the remaining quarter is used mainly for pigments in industry. The known quantity of soil samples were kept in the four mud pots in the laboratory conditions. The saplings of selected four terrestrial plants were planted in the experimental pots, and are considered as control (0 day) and they were allowed to grow in the laboratory conditions. The soil samples were tested for the presence of heavy metal cadmium before phyto-remediation (0 day) and it was found to be 1.87µg/g. The studies were carried out over a period of three months i.e., from September to November 2008. Sampling of soil from study area, were made for 90 days.

The methods adopted by (8) and (9), for analysis of heavy metal concentrations in soil samples, were followed. Standardization for cadmium-standard cadmium nitrate solution (1000µg ml^{-1} of cadmium). Dissolved 2.744g of cadmium (NO3)2. 4H2O in 100 ml of 1% nitic acid and diluted to 1L with 1% nitric acid method as followed by (10). One gram samples of dried and sieved materials were ashed in a muffle furnace at 460ºC for 24 hours. The weighed ash was digested in 10 ml aqua regia (1 part concentrated HNO_3 to 3 parts Hcl in a digestion tube on heating block for a total of 90 hours in the following sequence and duration of temperature two hours each at 25ºC, 60ºC and 105ºC and finally three hours at 125ºC. All digested samples were centrifuged; then made upto volume with 1% HNO_3. The method used for plant digestion is the same as described by (11). One samples of dried and ground plant material were ashed in a muffle furnace at 460ºC for 24 hours. The weighed ash was digested in concentrated HNO_3 and evaporated to near dryness on a hot-plate. Digested samples were centrifuged, then made upto volume with 1% HNO_3. Concentrations of the heavy metal Cd was measured in soil and plant samples by using Atomic Absorption Spectrophotometer (Perkin Elmer model, 1100).

RESULT AND DISCUSSION

In the initial stage (0 day), the concentration of heavy metal cadmium (Cd) was analysed and found to be 0.06, 0.02, 0.23 µg/g of respectively in the tissues namely, root stem and leaves of experimental plant *Datura innoxia*. At the end of experimental period (90 days), the concentration of cadmium was analysed and found to be 1.28, 1.06, 3.32 µg/g respectively in the tissues experimental plant (Table 1 and Fig. 1). In the initial stage (0 day), the concentration of cadmium was found to be 0.02, 0.15, 12.16 µg/g, respectively in the tissues namely root, stem and leaves of experimental plant *Acacia nilotica* and at the end of experimental period (90 days), the concentration of cadmium (Cd) was found to be 1.08, 1.02, 2.65 µg/g respectively in the tissues of experimental plant (Table 1 and Fig. 2). In the initial stage (0 day), the concentration of heavy metal cadmium was found to be 0.02, 0.12, 0.34 µg/g, respectively in the tissues namely root, stem and leaves of experimental plant *Ricinus communis*. At the end of experimental period (90 days), the concentration

Table 1. The concentration and accumulation (µg/g) of heavy metal (Cd) in terretrial plants, *Datura innoxia, Acacia nilotica, Ricinus communis, Calotropis gigantea* (before and after phytoremediation)

S. No	Tissues of Tested plants		Experimental Plants: *Datura innoxia*	*Acacid nilitia*	*Ricinus communis*	*Calotropis gigantea*
1	Roots	C	0.06	0.02	0.02	0.08
		T	1.28	1.08	1.02	0.82
2	Stem	C	0.02	0.15	0.12	0.02
		T	1.06	1.02	1.06	1.01
3	Leaves	C	0.23	12.16	0.34	1.23
		T	3.82	2.65	3.11	1.92

C – Control ; T – Treated

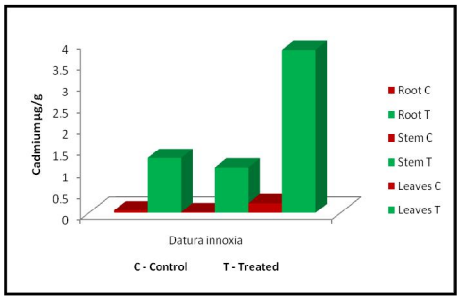

Fig. 1. Showing the concentration and accumulation (µg/g) of heavy metal (Cd) in terretrial plant *Datura innoxia* (before and after phytoremediation)

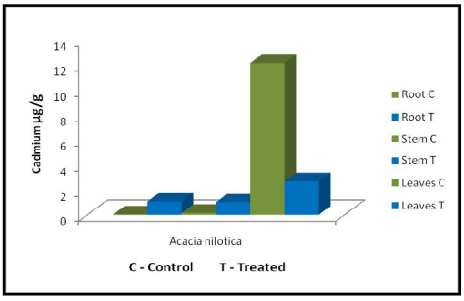

Fig. 2. The concentration and accumulation (µg/g) of heavy metal (Cd) in terretrial plant *Acacia nilotica* (before and after phytoremediation)

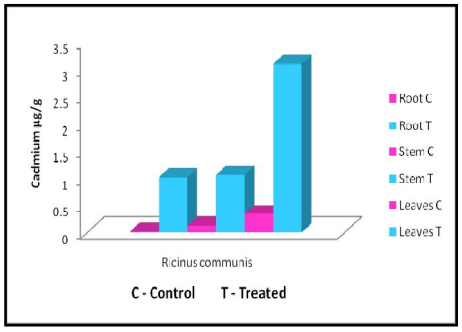

Fig. 3. The concentration and accumulation (µg/g) of heavy metal (Cd) in terretrial plant *Ricinus communis* (before and after phytoremediation)

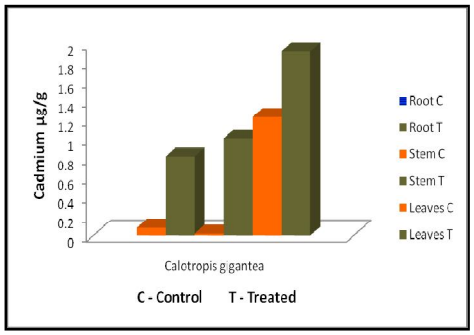

Fig. 4. The concentration and accumulation (µg/g) of heavy metal (Cd) in terretrial plant *Calotropis gigantea* (before and after phytoremediation)

of cadmium was found to be 1.02, 1.06, 3.11 µg/g respectively in the tissues of *Ricinus communis* (Table 1 and Fig. 3). In the initial stage (0 day), the concentration of cadmium was found to be 0.08, 0.02, 1.23 µg/g, respectively in the tissues namely root, stem and leaves of experimental plant *Calotropis gigantea* At the end of experimental period (90 days), the concentration of was found to be 0.82, 1.01, 1.92 µg/g respectively in the tissues of *Calotropis gigantea* (Table 1 and Fig. 4). From the present study, it was found that the heavy metal cadmium accumulation was more (3.32 µg/g) in leaves when compared to stem and roots of four experimental plants. Among the four selected experimental plants, *Datura innoxia* showed maximum accumulation of cadmium in all the three tissues namely roots, stem and leaves, when compared to the other three experimental plants, these findings are correlated with those of, (12) in *Datura innoxia*, (13) in *Acacia nilotica*, (14) in *Ricinus communis*, and (15) in *Calotropis gigantea.* In all the experimental studies, the leaves have shown quick absorption and record of heavy metal cadmium when compared to stem and root. It was reported earlier by (13) that Indian mustard removed more amount of zinc and equivalent amount of cadmium due to its larger size. All the tissues have shown lees quantity of Cadmium accumulation, while was more as reported earlier by (7) in *brassica* species.

The uptake of metal in plant (root and shoot) parts indicate that the soluble metals can enter into the root symplast by crossing the plasma membrane of the root endodermal cells or they can enter the root apoplast through the space between the cells. The solutes travel up through the plants by apoplastic flow by xylem. To enter the xylem, metal must cross a membrane, probably through the action of a membrane pump or channel. Once loaded into the xylem, the flow of the xylem sap will transport the metal to the aerial parts, where it must be loaded into the cells of the leaf, again crossing a membrane. Cadmium uptake is likely mediated through transporters or channels for other divalent ions reported by (16). Plants can contribute in many ways to enhance biodegradation in the soil. The present research study showed that during 90 days of exposure treatment, the heavy metal cadmium was depleted from the contaminated soil, suggesting absorption of cadmium metal by terrestrial plants. It has been noted that *Datura innoxia* is the suitable candidate plant for phytoremediation techniques, which has a lower biomass but accumulate a higher concentration of cadmium metal from the contaminated soil. Phytoremediation provides an aesthetically pleasing alternative to study remediation and decontamination technologies. As a result of these advantages, phytoremediation has considerable potential for environmental restoration of contaminated sites especially in the industrially polluted areas like SIPCOT industrial complex, Cuddalore, Cuddalore District, Tamilnadu, India.

REFERENCES

1. Schnoor, J, 1997. Phytoremediation: ground water remediation technologies. Analysis Centre Evaluation Report TE; 98-01, 37.
2. Peterson P.J. and Alloway B.J. 1979. The chemistry, biochemistry and biology of cadmium. M. Webb (ed.) pp. 45 – 62. Elsevier/North – Holland Biomedical Press. Amsterdam.
3. Vassilev AD. Kapulnik Y, Raskin I, and Salt DE, 1998. The role of EDTA in lead transport and accumulation by Indian mustard – *Plant Physiology*, 117: 447-491.
4. Blaylock M, Salt D, Dusenkov Y, Zakharova O, Gussman C, Kapulnik Y, Ensley B and Raskin I, 1997. Enhanced accumulation of Pb in Indian mustard by soil applied chelating agents. *Environmental Science and Technology*, 31: 860 – 865.
5. Greger M and Lindverg S, 1986. Effects of Cd^{2+} and EDTA on our sugar beets (*Beta vulgaris*) Cd2+ uptake and sugar accumulation. *Physiologia Plantarum*, 1986; 66: 69-74.
6. Cataldo DA, Garland TR and Wildurg RE, 1981. Cadmium distribution and chemical fate in soyabean plants. *Plant Physiology*, 68: 835 – 839.
7. Dushenkov V, Kumar PBAN, Motto H, and Raskin I, 1995. Rhizofilteration: the use of plants to remove heavy metals from aqueous streams. *Environmental Science and Technology*, 32(6): p. 802-806.
8. Berrow, ML and Ure, AH, 1981. The determination of metals and metalloids in soil. Environ. Tech. letters; 2: 485-502.
9. Paveley, CF and Davis BE, 1988. Comparison of results obtained by X-ray fluorescence of the total soil and acid digest in the routine determination of lead and zinc in soil. *Commun Soil Sci. and Plant Anal*, 19: 107-116.
10. Aziz-Alrahman, A.M., Hajjaji, AL., and Zmil, I.Z, 1982. Determination of Lead and Cadmium in soils by Atomic Absorption Spectrometry after solvent Extraction as iodide complexes. *International Journal of Analytical Chemistry*, 15 9-18
11. Al – Shayeb, SM, Al-Rajhi. MA and Seaward, MRD, 1995. The Date Palm (*Phoenix dactylifera* L.) as a biomonitor of lead and other elements in and environments. *Sci. Total Environ.*, 168: 1-10.

12. Lucero ME, Muller W, Hubstenberger J, Phillips GC, O' Connell MA, 1999. Tolerance to nitrogenous explosives and metabolism of TNT by cell suspension of *Datura innoxia*. In vitro cell. *Dev Bio Plant,* 35: 480-486.
13. Ebbs SD, and Kochian LV, 1998. Phytoremediation of zinc by oat (*Avena sativa*) barley (Hordeum vurgare), Indian mustard (Brassica Juncea). *Environmental Science and Technology,* Vol. 32, no. 6, p. 802-806.
14. Quartacci MF, Baker AJM, Navari – IZZO, F, 2005. Nitrilo triacetate and citric acid – assisted Phytoextration of cadmium by Indian mustard (*Brassica Juncea* L.) *Chemosphere,* V. 59, p. 1249-1255.
15. Krishnamurti GSR, Cieslinski G, Huang PM, Vanpees KCJ, 1997. Kinetics of cadmium release from soils as influenced by organic acids. Implication in cadmium availability. *Journal of Environmental Quality,* V. 26, p. 271-277.
16. Cosio C., Martinoia E., Kellar C., 2004. Hyper accumulation if cadmium and zinc in *Thlaspi caerulescens* and *Arabidopsis halleri* at the leaf cellular level. *Plant Physiol.*, 134: 716 – 725.

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